

REMARKS

By this amendment, claims 5 and 7-9 and Abstract have been amended, claims 6 and 10-12 have been canceled, and new claims 13-16 have been added to place this application in condition for allowance. Currently, claims 1-5, 7-9 and 13-16 are before the Examiner for consideration on their merits.

Applicants acknowledge the election of the Group I invention, and claims directed to the Group II invention have been canceled. Also, the Abstract has been amended as required by the Examiner.

Applicants respectfully traverse the rejections set forth in the Office Action. The traversal is made under headings discussing the invention, and the differences between the invention and the applied prior art.

INVENTION

The main objective of the invention is to provide an austenitic stainless steel that is excellent in high temperature strength and creep rupture ductility, and particularly wherein the creep rupture time exceeds 10,000 hours under the conditions of 700 °C and a load stress of 100 MPa, and the steel has a creep rupture reduction in area of 15% or more, see page 6, lines 15-21 of the specification. To emphasize the latter features of the invention, new claims 13-16 have been added to define the alloy composition in terms of these properties.

The invention has been obtained in light of the following realizations:

a) the dispersion strengthening and/or precipitation strengthening due to carbide, nitride and/or intermetallic compounds containing a large amount of Ti, promote non-

uniform grain sliding creep deformation at a high temperature of 700 °C or more thereby leading to a reduction in strength, ductility, and creep fatigue life;

b) when the microstructure of steel is coarsened and the grains are made uniform so that they have a small amount of mixed grains, the above-referenced non-uniform grain sliding creep deformation is suppressed. That is, when the microstructure is made of a structure of less than 7, ASTM grain size number, the non-uniform grain sliding creep deformation is suppressed. Particularly, when the microstructure of the steel is made of a uniform grain structure, having less than the ASTM 7 grain size and whose mixed grain ratio as defined on page 9, lines 13-16 of the specification is 10% or less, the non-uniform grain sliding creep deformation is further suppressed; and

c) a uniform grain structure having the ASTM grain size of less than 7 and the mixed grain ratio of 10% or less can be obtained by a combined addition of a very small amount of Ti and a suitable amount of oxygen (hereinafter "O"). Ti ranges from 0.002% to less than 0.01% with O ranging from 0.001% to 0.008%. With these added together, the above-referenced structure can be obtained. More specifically, the uniform grain structure can be obtained by controlling the amount of O mixed during steelmaking and adding a very small amount of Ti, the dispersion precipitating fine oxides of Ti. This is because the undissolved carbo-nitride of Ti is not generated. This mechanism takes place because the carbo-nitride of Nb is finely dispersion precipitated in steel using the stable fine oxide of Ti as a nucleus during middle heat treatment before final working, thereby generating uniform recrystallization during the final heat treatment, or to prevent the growth of non-uniform grains, which may lead to mixed grains. When no undissolved carbo-nitride of Ti is generated in the steel, the carbo-nitride of Nb, which is

nucleated from the fine oxide of Ti dispersed during the manufacturing, does precipitate finely and uniformly in grains and grain boundaries, during creep deformation in its use. As a result, the non-uniform creep deformation, which is generated at 700 °C or more, is suppressed, and at the same time, reduction in the creep rupture ductility and creep fatigue life can be significantly improved. As a result, it has been found that creep strength at high temperature is improved. Thus, in order to obtain an excellent high temperature strength and an excellent creep rupture ductility under the condition of a temperature of 700 °C or more, and a load stress of 100 MPa, it is very important to adjust the chemical composition of an austenitic stainless steel, especially in order to ensure the above-referenced properties are met. This is achieved by the following:

- A) Ti: 0.002% or more and less than 0.01%;
- B) Nb: 0.1 – 1.0%;
- C) O: 0.001 – 0.008%, and
- D) N: 0.1 – 0.35%.

Since the oxide of fine Ti becomes the precipitated nucleus of the carbo-nitride of Nb in softening heat treatment before final working, the carbo-nitride of Nb can be dispersion precipitated finely. Then, the finely dispersion precipitated carbo-nitride of Nb generates uniform recrystallization during the final heat treatment and prevents growth of non-uniform grains, which lead to mixed grains. Further, when no undissolved carbo-nitride of Ti is generated in the steel, the carbo-nitride of Nb, which is nucleated from the fine oxide of Ti dispersed during the steelmaking does precipitate finely and uniformly in grains and grain boundaries, during creep deformation and its use. As a result the non-uniform creep deformation, which is generated at 700 °C or more, is suppressed, and

the reduction in the creep rupture ductility and the creep fatigue life are significantly improved. As a result, the creep strength at high temperature is also improved. To form the stable fine oxide of Ti without generating a carbo-nitride, Ti of at least 0.002% is required. On the other hand, if the Ti content is 0.01% or more, unnecessary carbo-nitride is generated wherein the creep rupture ductility and the creep fatigue strength decreases, see page 16, line 7 to page 17, line 4 of the specification.

Nb is finely dispersion precipitated as carbo-nitride to contribute to the improvement in creep strength. Thus, to obtain this effect, the Nb content of at least 0.1% is needed. However, large amounts of Nb decrease weldability, especially if the Nb content exceeds 1.0%, the reduction in weldability is significant, see page 17, line 12 to 18 of the specification.

Oxygen is also important in the invention. To form the above-referenced oxide of Ti, an O content of at least 0.001% is needed. If more than 0.008% of O is provided, oxides other than oxides of Ti are formed. These other oxides become an inclusion which decreases creep rupture ductility and creep fatigue strength, see page 19, line 24 to page 20, line 3 of the specification.

Nitrogen is also critical to the invention and is added to ensure precipitation strengthening due to carbo-nitride and the austenite stability at high temperature in place of a part of expensive nickel. To improve tensile strength and creep strength at high temperature, the N content should be 0.1% or more. The addition of large amounts of N decreases ductility, weldability, and toughness, and the N content should not exceed 0.35%, see page 19, lines 8-17 of the specification.

Another feature of the invention is that the ASTM grain size should be 0 or more and less than 7, and the alloy should have a uniform grain structure with a mixed grain ratio of 10% or less. Creep of steel at temperatures of less than 700 °C is a dislocation creep in which the deformation in grains is main, and on the other hand, a creep of the steel at a temperature of 700 °C or more causes a grain sliding creep. In a fine grain structure having an ASTM grain size of 7 or more, a grain sliding creep is produced to lower strength significantly and an aimed creep rupture time cannot be ensured. Alternatively, in a coarse grain structure having an ASTM grain size of less than 7, but more than 0, not only is strength and ductility impaired, ultrasonic testing of products cannot be done. Further if the mixed grain ratio exceeds 10%, non-uniform creep deformation is generated thereby lowering the creep rupture ductility and creep fatigue strength, and the target creep rupture time cannot be obtained, see page 23, line 24 to page 24, line 13 of the specification.

CLAIMS 1-4

Differences with Hirata

In the rejection, the Examiner alleges that JP 2001 107196 to Hirata establishes a *prima facie* case of obviousness against claims 1-4 on the basis of an overlap in composition ranges.

Notwithstanding any alleged overlap, the claimed composition has critical amounts of Nb, N, O, and Ti for claims 1-4, and this criticality which is supported by the comparative evidence in the specification rebuts any allegation of obviousness based on Hirata.

In particular, the comparative evidence shows criticality for at least Ti, O, and N. Referring to Tables 1-3 and the evidence regarding Ti, it is clearly demonstrated that alloy compositions outside the claimed range of Ti do not provide the desired creep rupture time, or reduction in area. Alloy Nos. 31 and 32, each outside the claimed range of Ti, have poor creep rupture reduction in area and inadequate creep rupture time, respectively.

Alloy No. 33 having an O content within the suggested range of Hirata has inadequate creep rupture reduction in area.

Alloy No. 30 has a nitrogen content falling with the teachings of Hirata but is outside of the claimed range, and this alloy has inadequate creep rupture time.

This comparative evidence shows that the claimed ranges for Ti, O, and N are critical in achieving the aim of the instant invention. This also means that obtaining these ranges is inventive, and is not merely an obvious modification of the composition of Hirata.

While the argument above is believed to be persuasive, it is also argued that Hirata does not even establish a *prima facie* case of obviousness on the grounds that it is directed to a completely different problem and solution as the instant invention. That is, Hirata is concerned with weld cracking resistance in a sulfuric acid environment. In order to obtain this goal, Hirata controls a number of alloying elements as detailed in paragraphs [0019-0023], [0028], [0031], [0034], [0036], and [0037].

In particular, Hirata requires one or more of the elements of Nb, Ta, Ti, and Zr to be 0.1-0.5%, N less than or equal to 0.1%, and O less than or equal to 0.1%. The use of one or more of Nb, Ti, Ta or Zr fixes the carbon as carbides in the weld metal and

complicates the configuration of grain boundaries for weld cracking resistance. N is employed for strengthening purposes by precipitation of nitrides. However, N can cause embrittlement so it is limited to 0.1% or less, with more preferred limits of 0.08% and 0.06%.

O is considered an unavoidable impurity by Hirata since its presence can affect steel cleanliness, and cause embrittlement. Thus, O is limited to 0.1% or less with preferred limits being 0.08% and 0.06%.

The teachings of Hirata do not lead one to the invention in terms of controlling the Ti, O, N, and Nb as described above. Particularly, one of skill in the art would not be led to use a N range given Hirata's teachings, and if anything, Hirata would teach away from using more N. Thus, it is submitted that given the fundamental differences between the aims of Hirata and the instant invention, Hirata does not suggest the invention by its mere disclosure of various ranges of elements.

Differences with Wilhelmsson and NKK

In the second rejection, the Examiner alleges that it would be obvious to control the oxygen of the composition taught in United States Patent No. 4,560,408 to Wilhelmsson given the teachings of JP 01 361045 to NKK.

This rejection fails for the same reason that the rejection based on Hirata fails, and it fails regardless if NKK is properly combined with the primary reference. That is, the comparative showing in the specification demonstrates that the claimed limits of N, O, and Ti are critical and this showing effectively rebuts any allegation of obviousness. The invention is more than reducing oxygen to zero as demonstrated above, oxygen

must be present in the claimed lower limit amount in order to function in its intended manner with Ti.

Moreover, it is also argued that the rejection fails since a *prima facie* case of obviousness is not established. That is, Wilhelmsson is directed to an austenitic manganese-alloyed construction material for use at high temperatures and sulfuric acid environments. For resistance to sulphidation, the manganese is controlled to 3-12%, and titanium is added to increase strength by formation of carbides. However, there is no recognition of the importance of Ti, O, N, and Nb, and their collective effect on creep rupture properties. Therefore, it is contended that one of skill in the art would not be motivated to set the limits of O, Ti, Nb, and N as detailed in claims 1-4, and the rejection is flawed for this reason.

Differences with Kimura and NKK

As with the two rejections discussed above, the rejection of claims 1-4 based on JP 2002 069591 to Kimura when taken in view of NKK is flawed. That is, the showing in the specification rebuts any contention of obviousness, regardless of whether NKK is properly combined with Kimura.

The reasoning set forth above regarding a lack of a *prima facie* case of obviousness is also incorporated in this traversal. Kimura teaches an alloy that has controlled amounts of C, Si, Mn, Cr, Ni, Co, Mo, W, N, and Cu. Notably, Ti and Nb are optional. More notably is the fact that the carbon content sets a maximum of 0.02% whereas the claim requires at least 0.03%. Since there is no overlap in carbon content, Kimura cannot establish a *prima facie* case of obviousness for this reason alone.

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Further, since Kimura desires lower carbon, one of skill in the art would not be taught to raise the carbon level in Kimura.

NKK does not make up for the deficiencies in Kimura, and even if combined with this reference, obviousness is not established.

CLAIMS 5 and 7-9

In the rejection, the Examiner relies on United States Patent No. 4,437,900 to Petkovic-Luton (PL) to allege that it would be obvious to employ an ASTM grain size of 2 to 6 in the composition of any one of modified Hirata, Kimura, or Wilhelmsson.

Applicants contend that this rejection is flawed for two reasons. First, there is no motivation to make such a rejection, and second, the comparative evidence in the specification shows that controlling the grain size and mixed grain ratio results improvements that are unexpected in the prior art.

First, claims 5 and 7-9 also define a mixed grain ratio of 10% or less. The rejection does not even address this limitation, and the rejection fails for this reason alone. The Examiner is requested to provide objective support for any further rejection of claims 5 and 7-9 regarding the obviousness of the mixed grain ratio claim limitation found in these claims.

Second, PL is concerned with a cast austenitic heat resistant alloy that has superior strength and ductility at elevated temperatures and creep properties when exposed to carburizing or oxidizing environments. This is accomplished by adjusting the as-cast microstructures to have relatively coarse grain equiaxed grains of ASTM 6 to 2. Moreover, this alloy has a carbon content of between 0.25 and 0.55%, well outside the claimed

range. It is submitted that one of skill in the art would not look to the teachings of PL regarding a cast structure, and use its grain size preference in compositions such as Kimura, NKK, Wilhelmsson, all of which are concerned with wrought compositions or Hirata which is a welding material. The Examiner is applying hindsight to formulate the rejection, and this practice makes the rejection untenable.

CLAIMS 13-16

New claims 13-16 are also not suggested by the applied prior art. None of the references teach or suggest the properties of these claims, and they cannot establish obviousness. Moreover, it is demonstrated in the specification that only certain alloy compositions achieve these results so the Examiner cannot take the position that they would be inherent in the compositions of the cited prior art.

These claims are also patentable by virtue of the fact that these improved properties are not expected in light of the teachings of the prior art, and developing an alloy with such properties is a clear rebuttal of any *prima facie* case of obviousness that may be established by any of the cited prior art.

DOUBLE PATENTING REJECTION

Applicants note the double patenting rejection. However, it is respectfully contended that the invention is not an obvious variant of related application no. 10/829,274 (the related application). There are a number of differences between the instant claims and claims 2, 4, and 5 of the related application. The related application teaches the control of copper, aluminum, phosphorous and vanadium in attaining its

sought-after properties. The control of these elements is nowhere to be found in the instant application, and it is not seen how the instant claims are obvious variants of claims 2, 4, and 5 of the related application. Therefore, the obviousness-type double patenting rejection should be withdrawn. If the Examiner persists in making this rejection, the Examiner is called upon to support any further rejection with objective facts and reasoning.

SUMMARY

By the arguments set forth above, it is respectfully submitted that the applied prior art either fails to establish a *prima facie* case of obviousness against the pending claims or that the comparative evidence set forth in the specification rebuts any and all allegations of obviousness, thus making claims 1-5, 7-9 and 13-16 patentable. Moreover, the obviousness-double patenting rejection is improper and should be withdrawn.

Accordingly, the Examiner is respectfully requested to examine this application in light of this amendment and pass all pending claims onto issuance.

If the Examiner handling this application believes that an interview would help expedite allowance of this application, the Examiner is invited to telephone the undersigned at 202-835-1753.

The above constitutes a complete response to all issues raised in the Office Action dated September 17, 2004.

Again, reconsideration and allowance of this application is respectfully solicited.

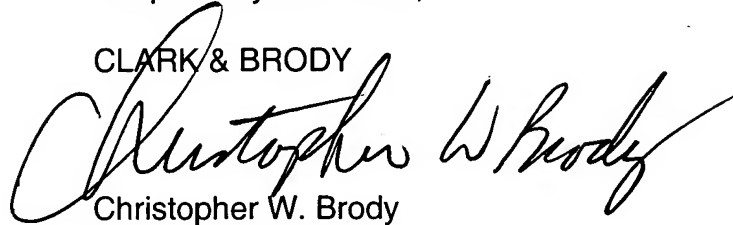
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Respectfully submitted,

CLARK & BRODY

A handwritten signature in black ink, appearing to read "Christopher W. Brody". The signature is fluid and cursive, with the first name being the most prominent.

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